

INFLUENCE OF CHEMICAL AND MINERAL ADMIXTURES ON SHRINKAGE AND CREEP OF PREPACKED AGGREGATE CONCRETE

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I would like to dedicate this project report
to my beloved family

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ABSTRACT

Prepacked aggregate concrete is a special kind of concrete which is produced by first placing the coarse aggregates inside the molds followed by injection of grout from underneath using pump or gravity method. The grout consists of sand, cement and water plus chemical and mineral admixtures. Two separate stages are included in this study: The first stage consists of manufacturing of grouts with superplastizer as chemical admixture and palm oil fuel ash as mineral admixture. Tests were conducted on grouts to examine bleeding, density, compressive strength, consistency, volume change properties. In the second stage, prepacked aggregate concrete samples were made following grouting by two methods: pump and gravity. Once the specimens were made, shrinkage and creep tests were performed following ASTM C512/C512 M-10. It has been found that the shrinkage and creep of prepacked aggregate concrete was lower than that of normal concrete in both gravity and pump specimens using chemical and mineral admixtures.

ABSTRAK

Agregat konkrit Prepacked adalah sejenis khas konkrit yang dihasilkan dengan terlebih dahulu meletakkan agregat kasar dalam acuan diikuti dengan suntikan grout dari bawah dengan menggunakan pam atau kaedah graviti. Grout ini terdiri daripada pasir, simen dan air serta bahan tambah kimia dan mineral . Dua peringkat yang berasingan termasuk dalam kajian ini : Peringkat pertama terdiri daripada pembuatan grouts dengan superplastizer sebagai campuran bahan kimia dan abu bahan bakar minyak sawit sebagai bahan tambah mineral. Ujian dijalankan ke atas grouts untuk memeriksa pendarahan, ketumpatan, kekuatan mampatan, konsisten , harta perubahan kelantangan. Dalam peringkat kedua, prepacked sampel agregat konkrit telah dibuat berikutan grouting dengan dua kaedah : pam dan graviti. Setelah spesimen yang telah dibuat, pengecutan dan rayapan ujian telah dijalankan berikutan ASTM C512/C512 M- 10. Ia telah mendapati bahawa pengecutan dan rayapan konkrit agregat prepacked lebih rendah berbanding konkrit biasa dalam kedua-dua graviti dan spesimen pam menggunakan bahan tambah kimia dan mineral.

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LIST OF SYMBOLS

$S_{(t)}$	Shrinkage after drying time t
S_{00}	final shrinkage according to the cement percentage of the concrete
s	rate of shrinkage which depends on the RH (Relative Humidity) of the lab
ρ	cement paste percentage of the grout
V_1	sample volume at the beginning of the test, mL
V_2	sample volume at intervals taken from the upper surface of the bled water, mL
V_g	grout volume at intervals from the upper surface of the grout, mL
$Sh(t, t_0)$	Shrinkage value
$\varepsilon(t)$	Shrinkage at time t
$\varepsilon(t_0)$	shrinkage at time t_0
M	Coefficient of DEMEC gauge
$C(t, t_0)$	Creep value
$\varepsilon_c(t)$	Creep at time t
$\varepsilon_c(t_0)$	creep at time t_0
$C_T(t, t_0)$	Total creep
$\varepsilon_{sh}(t)$	Shrinkage at time t
C_s	Specific creep
σ	Applied stress (MPa)

CHAPTER 1

INTRODUCTION

1.1 Background to the research

Pre-packed aggregate concrete (PAC) is a concrete which is prepared by injecting grout from underneath of a set of clean-placed coarse aggregates inside the formwork. The coarse aggregates are placed densely inside the formwork. PAC is used where common methods of placing concrete is not feasible such as huge reinforcing concrete structural members, underwater concreting, concrete and masonry repair and finally where creep and shrinkage of the member is crucial to be minimum in the design. Moreover, this method is applicable in underwater structures, mass concreting where a smaller amount of heat of hydration and cement content is required. Another application of PAC is in tunnel and sluiceway plugs where high pressure water is present and therefore, low shrinkage is in our interest (King, 1959). PAC is also used in atomic radiation shielding that employs high density concrete, heavy metallic ores and steel as coarse aggregates (Taylor, 1965).

Creep and shrinkage are time dependent phenomena which occur in concrete structural members. Viscoelastic materials undergo a time dependent deformation in excess of initial elastic strain as a result of sustained applied stresses. On the contrary, shrinkage is the deformation of a structural member over time in absence

of applied stresses. Hence, the total strain of a concrete specimen is determined through the summation of initial elastic strain, creep strain and shrinkage strain.

In order to reduce the shrinkage and creep of concrete, several solutions are offered by scientists. One method is to increase the aggregate/cement ratio (a/c). Another way is to reduce the water-cement (w/c) ratio by means of superplasticizer (SP). Hence, the water and cement content of the specimen will decrease. As it turns out, the reduced volume of cement is responsible for shrinkage and creep of concrete specimens. This reduction in cement content of the grout will be made up by means of higher proportion of aggregates to lower the speed of shrinkage and creep of concrete (Borsoi,2009).

The recent interest in incorporating mineral admixtures has persuaded officials to study the effect and structure of mineral admixtures on concrete. There are two major reasons for such an act: first, better economy results from the use of mineral admixtures since they are abundant in nature. Second, these admixtures are not environmentally friendly and their disposal will pose environmental pollutions. When they are used in concrete technology, the cement consumption will decrease and hence, the carbon dioxide of the atmosphere will decrease as well (Ferraris,2001).

The consumption of pozzolanic materials has long been in use. Pozzolans are either natural or artificial. One such artificial pozzolan is fly ash. Fly ash is a widely recognized pozzolanic material which has become so popular around the world. Incorporating fly ash in concrete will produce highly workable concretes. In addition to fly ash, there are other pozzolanic materials which belong to this family. One such pozzolanic material is palm oil fuel ash (POFA), which is obtained from burning palm oil husk and palm kernel shell as fuel in palm oil mill boilers. POFA has a great extent of silica in its micro structure which makes it a great pozzolanic material (Awal and Hussin, 2009).

According to ASTM C618- 94a (1994), POFA may be classified between class C and class F.

1.2 Problem Statement

A higher amount of coarse aggregates will lead to lower shrinkage and creep of PAC. Since the aggregates are in close contact, they directly bear the load and affect the shrinkage and creep of the concrete which is lower than normal concrete. PAC has long been in use for dam projects, piers, retrofitting structures, underwater concreting and so on. However, over this long period, lots of issues have been addressed as problems regarding the creep and shrinkage of PAC. Questions like: how to increase the fluidity of the grout without having extreme shrinkage and creep? What sort of grading can be used to improve the creep and shrinkage behavior of PAC? What sort of admixtures can be used to improve creep and shrinkage properties of PAC? What proportion of water-cement and cement-sand can be used to improve the fluidity of the grout?

1.3 Objectives of Study

The objectives of this research are listed as below:

1. To manufacture grouts with high fluidity and proper water-cement and cement-sand ratios incorporating suitable amounts of mineral and chemical admixtures.
2. To conduct tests on the grouts in terms of bleeding, density, compressive strength, consistency and volume change properties.
3. To make PAC cylinders and test their creep and shrinkage according to the relevant standards and compare them with control cylinders.

1.4 Scope of Study

The scope of this research can be summarized as follows:

1. Manufacture of several suitable grouts using chemical and mineral admixtures to promote their workability and consequently, the strength of PAC. Also, time of efflux of the cement grout is derived through the use of a standardized flow cone which is used for PAC in accordance with ASTM C939-10.
2. Making PAC and normal concrete specimens according to the following mix proportion:

PAC: coarse aggregate 1321 kg, fine aggregate 548 kg, cement 378 kg, water 197 kg.

Normal concrete: coarse aggregate 1095 kg, fine aggregate 774 kg, cement 378 kg, water 197 kg.
3. Replacement of cement by trial amounts of POFA and super plasticizers.
4. Keeping the cylinders intact for 20 to 48 hours before demolding. Then, the specimens will be cured in a moist condition for 7 days.
5. The creep and shrinkage tests will be performed following the specifications of ASTM C512/C512M-10 and ACI Committee 209.

1.5 Significance of Study

One of the benefits of using PAC is the reduced costs to almost 25% - 40% comparing to normal concrete. This lower cost results from the reduction of cement by 30% compared to normal concrete. However, this reduced amount of cement does not impose any changes on mechanical properties of PAC. What's more, improved flow characteristics and better economy result from the use of mineral admixtures in PAC. Also, drying shrinkage is reduced by the use of chemical admixtures. For example, reduced number of cracks and reduced-width cracks in retrofitting structural members is a function of applying chemical admixtures.

Creep and shrinkage are two properties of concrete which need great care. These two properties are time-dependent and based on the amount of coarse aggregates and amount of water in cement paste. In PAC, since the amount of coarse aggregates is more than conventional concrete, creep and shrinkage will be decreased significantly. Also, by applying chemical admixtures like superplasticizer, the water content will decrease and therefore, creep and shrinkage will decrease as well. Hence, incorporation of PAC will help solve the problem of creep and shrinkage to a great extent.

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